ANALYSIS OF RETURNED ASTEROID SAMPLES: DYNAMICAL EVOLUTION OF ASTEROIDS, YORP, AND TIDAL FORCES

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Introduction: ORISIS-REx (O-REx) and Hayabusa 2 (HYB2) are both sample return missions with the primary goal of analyzing materials containing the pre- and post-accretional history of low albedo asteroids. A key challenge for the missions is to use geochemical constraints derived from the returned samples to test dynamical modeling work of precisely how the target asteroids evolved from the main asteroid belt to their observed orbits near Earth. In addition, a comparison between these data and those from meteorites recovered on Earth may help us better understand how their parent bodies formed in the solar nebula, how they were affected by subsequent collisional evolution, and the processes that allowed their fragments to reach Earth. These samples may also allow us to explore whether O-REx and HBY2 are sampling fragments derived from the same main belt parent body [1].

Discussion: As an example, consider the analysis of Hayabusa particles, which allow us to probe and constrain the dynamical evolution of Itokawa. They show that the cosmic-ray exposure (CRE) ages of the regolith grains are uniformly brief, < 8 Ma [2 and references therein]. We infer that Itokawa's surface has been rejuvenated recently, but the precise process is unknown. Interestingly, we find that some Hayabusa grains are round, suggestive of a geologically high-energy environment required to mechanically weather rocks. One process suggested to produce these grains is seismic shaking due to impacts [3], but the observational evidence for abundant impacts is lacking. We suggest that YORP spin-up and planetary tidal forces during close encounters produced repeated re-surfacing events on Itokawa (and other NEAs) [4]. These same processes may have also produced numerous mass shedding events that ultimately led to the delivery to Earth of many different meteorite types with short CRE ages.

References: [1] BOTTKE et al. 2015. Icarus 247: 191. [2] BUSEMANN et al. 2015. 46th *Lunar Planet. Sci. Conf.* #2113. [3] TSUCHIYAMA et al. 2011. *Science* 333: 1125-1128. [4] CONNOLLY H. C. et al. 2015. *Earth, Planets and Space* 67: 12-18.